
# Proposal for the AMANDA IceCube Synchronization


- Overview and review
- New proposed method
- Test Setup
- Time-line and needed support

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# Synchronization Overview & Requirements


**Aim:** Need to be able to relate the times of Hits in AMANDA and IceCube with sufficient accuracy

Initial Requirements and Strategies defined in:
Amanda/IceCube Integration Plan, section 5
(C.Spiering, Version July 12, 2004)

⇒ Minimum requirement: $\delta t \leq 10$ ns
(for unified track reconstruction)

However, 10ns would significantly contribute to the resolution and systematics. A smaller and if possible negligible uncertainty is thus desirable: $\delta t << 10$ns

⇒ No systematic uncertainty for track reconstruction
⇒ Precise systematic studies/cross calibrations possible

Another concern: robustness/redundancy of the system -> backup
Also: The synchronization should be available online


# Previously proposed methods (1)


Synchronization offline using the information from the two independent AMANDA/IceCube GPS-clocks in the data streams (AIP option 1).

- Even 10ns may be difficult to achieve
- Not reliable, i.e. the clocks see different satellites
- Not supporting the integration tasks and future extension, e.g. common trigger, event merging

$\Rightarrow$ Use only as a (desperate) backup option

called in the following: **NONO-option**

# Previously proposed methods (2)

Synchronization online: using the Master clock unit of IceCube. The GPS signals are transferred to MAPO in a DSB like fashion. A 100 MHz synchronous clock is generated and distributed to the TWR (AIP option 4).

⇒ Essential part of this proposal, called in the following:

**GPS-DSB option**

Advantages:

- Solves the problem with (almost) the required resolution 10ns
- Improves also the internal TWR Daq synchronization
- A good step towards merging events online

Disadvantages:

- Relies on a very time stable and reliable connection to the IceCube master clock.
- Needs monitoring, calibration and a backup in case of cable failure/clock failure (at least to allow for offline synchronization)
- Improvement of resolution desirable
- Uses optical cables to MAPO and needs new hardware in MAPO


# Previously proposed methods (3)


Synchronization by exchanging time-stamps between AMANDA and IceCube.
The AMANDA Trigger signal is digitized with a synchronized DOM-mainboard (RAP) in MAPO. Alternatively a TWR software generated signal is measured. The same signals are also measured by the TWR-DAQ (+$\mu$-DAQ) (= AIP options 2 & 3)

- This is part 2 of this proposal, called in the following:
  **DOM-SYNC option**

Advantages:

- This will always work, standard solution in accelerator experiments
- No (major) invention of new hardware
- Will eventually provide the best achievable resolution: $\delta t \sim ns$

Disadvantages:

- Online synchronization requires processing and correcting of data
- Needs new (IceTop-like ?) electrical cable to MAPO or reinvention of RAP-Cal for optical fibers.
- Trigger signal is random, probably ambiguous, but the software signal not available on an event to event basis.


# New Proposal


Integrated solution by merging the advantages of GPS-DSB with the DOM-SYNC option (and thus avoid the disadvantages) and essentially implement both:

A priori synchronize the TWR system (GPS-DSB option) but still exchange time-stamps as a backup, cross check and to achieve the optimum resolution offline (DOM-SYNC option).

- Redundant system
- Solves online requirements
- Optimum offline resolution
- Relatively small upgrade


# GPS-DSB option details


Upgrade existing AMANDA GPS2VME interface (H.Leich)

⇒ new GPS interface board "**GPS4TWR**" for AMANDA

- New optical inputs for 10MHz, 1Hz, and Time-string. Connect GPS4TWR similar to DSB cards
- A single master GPS4TWR module implements PLL and driver circuits for a 100MHz clock, distributed as ECL signals.
- The clock is fed into to simple converter/fan-out modules in each crate which distribute it to all TWR in one crate via a special backplane (development by H.Leich/K.H.Becker)
- TCP/IP interface for external access, e.g. new firmware
- Generate "software sync", e.g. $\tau \sim$ ms - s, (for DOM-SYNC option)
- Possibility to input AMANDA GPS clocks as backup (NONO-option) by additional inputs to GPS4TWR, input selectable by software


# GPS-DSB summary


With the GPS-DSB option, AMANDA-II runs similar to IceCube. DOR-like timesync signals are generated by GPS4TWR, and signals are captured with respect to the 10MHz clock derived from the IceCube GPS. The TWR-Modules thus act like ATWDs.

Requires:

- New GPS4TWR module
- New VME backplane, Fan-Out module
- Use of optical fibre connections from IceCube to MAPO
- Box which receives the IceCube master clock via RJ-45 connector and outputs signals to an optical driver (multi-mode, ST-connector). Existing?

⇒ provides online synch ~10ns (?) in an elegant way improving also the TWR system without changes to the TWR and IceCube DAQs

# DOM-SYNC option

1. Regular strobe
   - Generate a regular strobe signal by the GPS4TWR module
   - Measure strobe signal simultaneously by an ATWD- and TWR-channel in MAPO
   - Define asynchronous *"Synchronization event"* for both TWR and IceDaq, if this channels triggers
2. Trigger time stamp
   - Measure DMAD-trigger signal simultaneously with an ATWD and a TWR channel in each event
   - Determine relative offset in each event individually with an accuracy only limited by the digitization hardware
   - Measurement also possible with μ-DAQ.

Requirements:

Need 2 Rap-calibrated ATWD channels in MAPO, read out by the IceDaq (1 or 2 DOM boards ?), twisted quad cable (like IceTop?) to MAPO. Minor changes to both DAQ systems.


# The electrical cable


We request an electrical cable from IceCube to MAPO to connect a Rap-calibrated DOM Board

- We are aware that having an electrical conection to MAPO involves the danger of a ground loop
- The problem is: Guaranteed Galvanic decoupling of the DOM-Board from MAPO
- E.g. transformer or optical signals may be injected into the DOM board – *We accept whatever is wished*

A Rap-cal synchronized DOM-board is *the natural solution* and it is already known to work. All other approaches e.g. optical fibers, require major developments, test of stability and continuous monitoring (extra system) and reinventing an already existing solution.

A strict procedure which ensures a reliable galvanic decoupling is required but would allow us to follow the natural solution and save also resources at the pole.

# Test setup @ Wuppertal

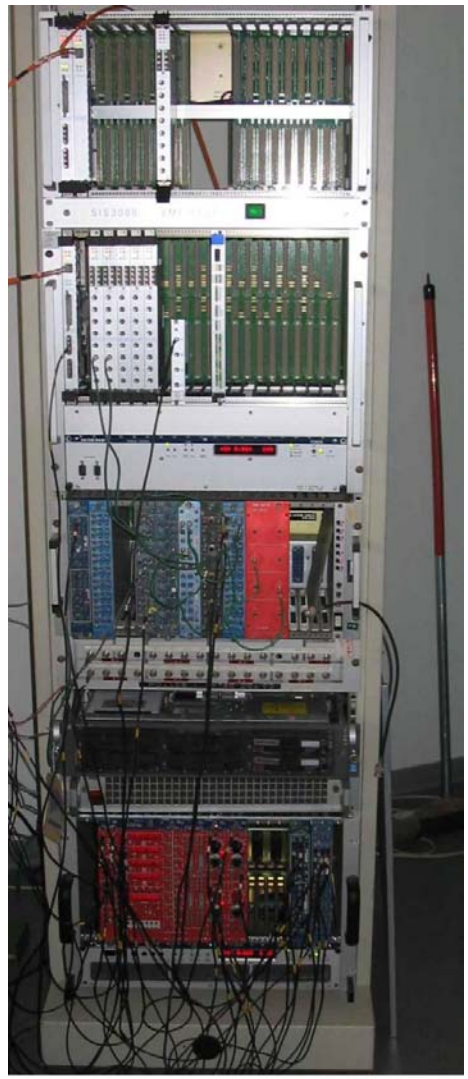
## Aim:

Possibility to develop and test the full synchronization scheme in the northern hemisphere.

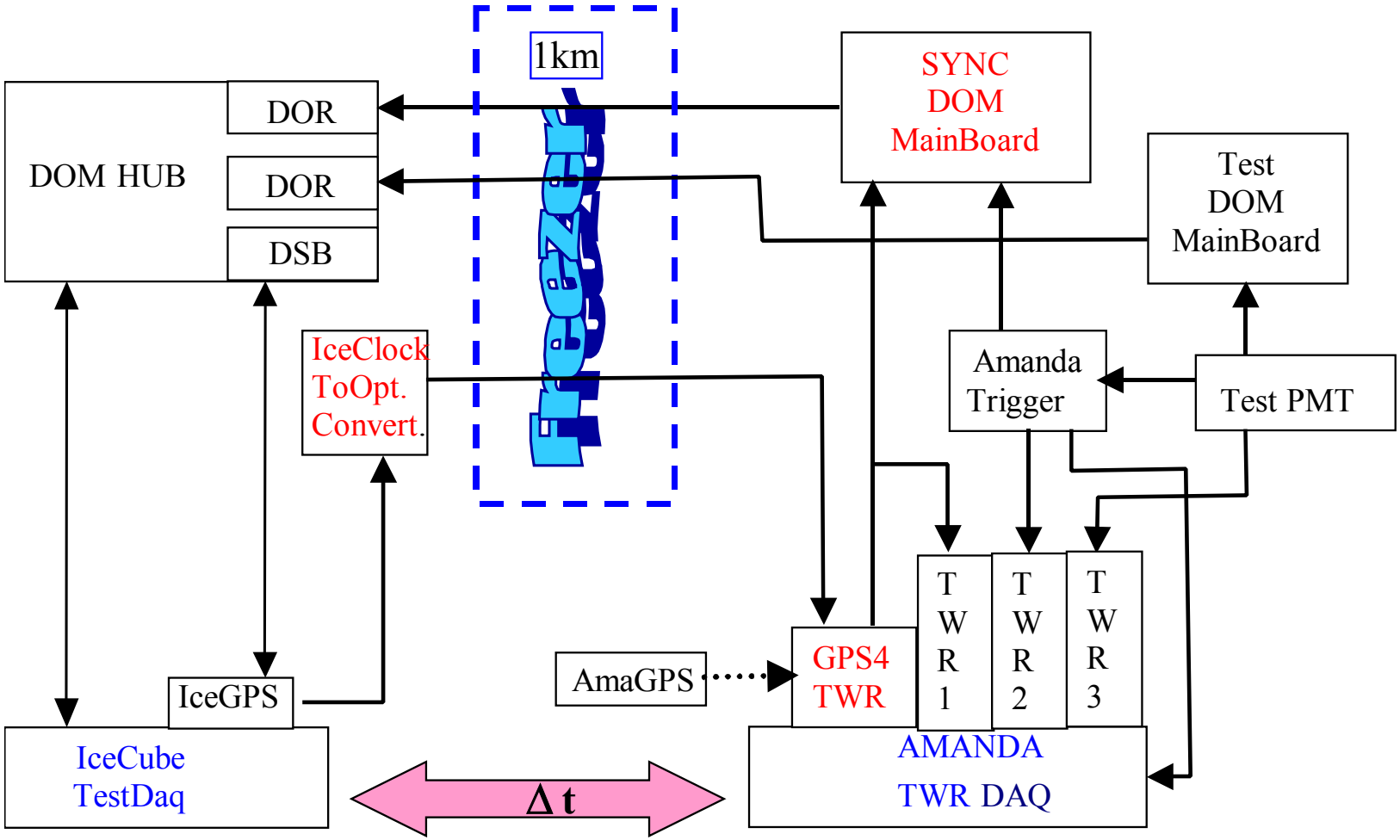
- Long term test of stability and drift
- Realistic test for GPS-DSB and DOM-SYNC
- Measure resolution of GPS-DSB and DOM-SYNC

## Requires:

- TWR DAQ
  -> Existing
- IceDaq, DSB, DOR, DOM
  -> needed anyway for DOR/DSB production and tests in Wuppertal
- Fridge,realistic cable, GPS, Connectors,Software...



# Planned Development and Test Setup




# Needed Support


- Allocation of 3 optical links to MAPO (existing ?)
- 1 twisted quad cables to MAPO (or similar)

- Electro-optical converter for IceCube clocks: Already existing ?

- 1 DOM-HUB incl. DOR+DSB
- 1-2 DOM-Board, one DOM
- 1 km realistic twisted quad cables (Unarmed? IceTop?)
- Connectors, special cables
- IceCube GPS clock for NH test-setup (probably not mandatory)

- Support from IceDaq and TWR DAQ to read out special channels

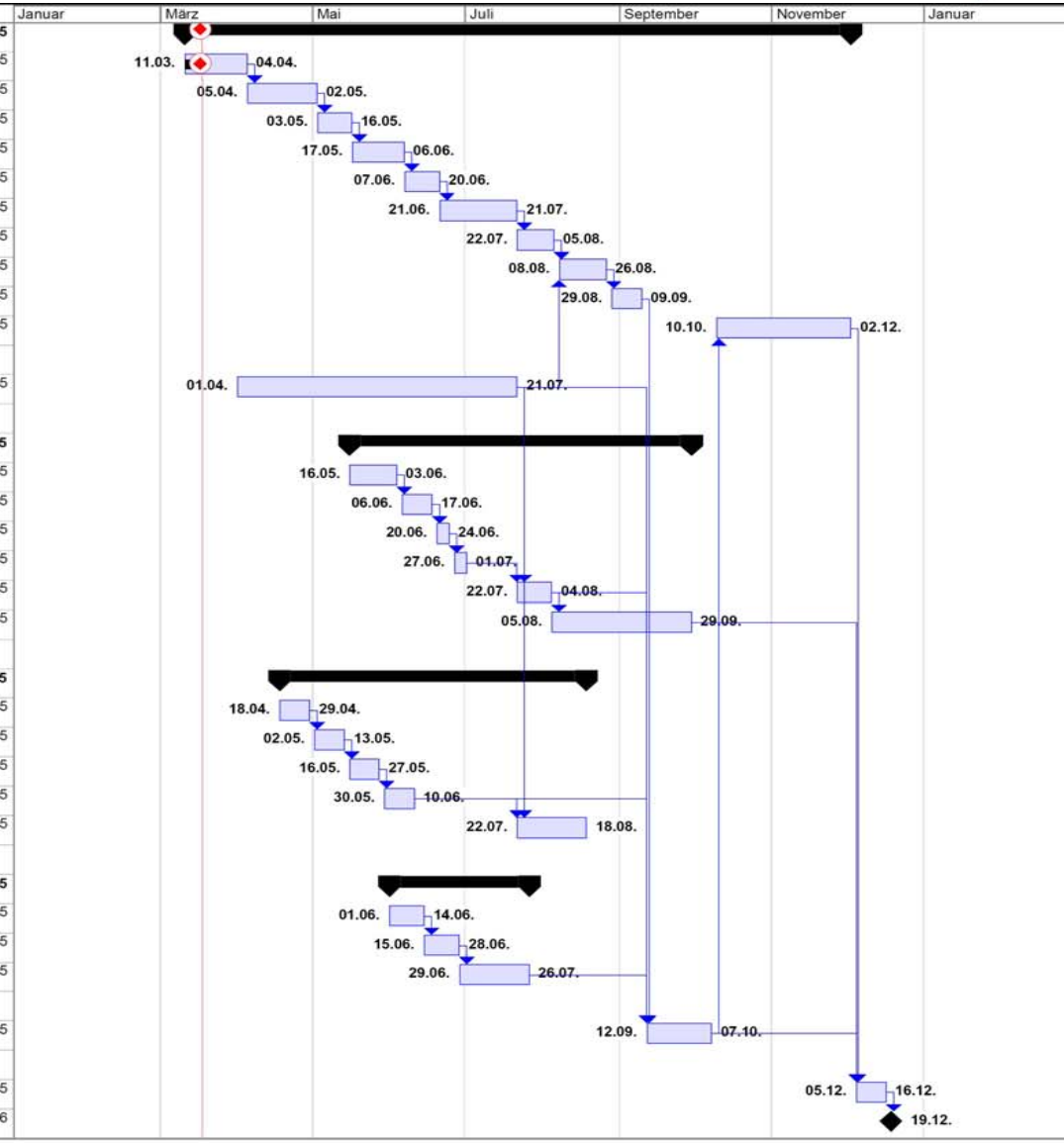
- Decision on this procedure ASAP

# Timeline

IceCube

AMANDA

| Nr. | Vorgangsname | Dauer | Anfang | Ende |
|---|---|---|---|---|
| 1 | **GPS4TWR** | **191 Tage** | **Fre 11.03.05** | **Fre 02.12.05** |
| 2 | GPS4TWR Functionality | 17 Tage | Fre 11.03.05 | Mon 04.04.05 |
| 3 | Schematic design ready | 20 Tage | Die 05.04.05 | Mon 02.05.05 |
| 4 | board layout design | 10 Tage | Die 03.05.05 | Mon 16.05.05 |
| 5 | PCB Production | 15 Tage | Die 17.05.05 | Mon 06.06.05 |
| 6 | Module assembly (In Zeuthen WS) | 10 Tage | Die 07.06.05 | Mon 20.06.05 |
| 7 | 3 Prototypes + Firmware tested (2x Wu | 23 Tage | Die 21.06.05 | Don 21.07.05 |
| 8 | Prototype delivery to Wuppertal (2x) | 11 Tage | Fre 22.07.05 | Fre 05.08.05 |
| 9 | Prototype test at Wuppertal | 3 Wochen | Mon 08.08.05 | Fre 26.08.05 |
| 10 | Minor Prototype Modifications | 2 Wochen | Mon 29.08.05 | Fre 09.09.05 |
| 11 | Production 8 SP Modules | 2 Monate | Mon 10.10.05 | Fre 02.12.05 |
| 12 | | | | |
| 13 | Test Setup in Wuppertal | 4 Monate | Fre 01.04.05 | Don 21.07.05 |
| 14 | | | | |
| 15 | **VME Backplanes** | **99 Tage** | **Mon 16.05.05** | **Don 29.09.05** |
| 16 | Schematic design | 0,75 Monate | Mon 16.05.05 | Fre 03.06.05 |
| 17 | board layout | 2 Wochen | Mon 06.06.05 | Fre 17.06.05 |
| 18 | PCB Production | 1 Woche | Mon 20.06.05 | Fre 24.06.05 |
| 19 | Assembly | 1 Woche | Mon 27.06.05 | Fre 01.07.05 |
| 20 | Prototype test at wuppertal | 2 Wochen | Fre 22.07.05 | Don 04.08.05 |
| 21 | Production of 8 Backplanes | 2 Monate | Fre 05.08.05 | Don 29.09.05 |
| 22 | | | | |
| 23 | **GPS2Optical Converter** | **89 Tage** | **Mon 18.04.05** | **Don 18.08.05** |
| 24 | Functionality | 2 Wochen | Mon 18.04.05 | Fre 29.04.05 |
| 25 | Schematic Design | 2 Wochen | Mon 02.05.05 | Fre 13.05.05 |
| 26 | Layout | 2 Wochen | Mon 16.05.05 | Fre 27.05.05 |
| 27 | Assembly | 2 Wochen | Mon 30.05.05 | Fre 10.06.05 |
| 28 | Test in Wuppertal | 1 Monat | Fre 22.07.05 | Don 18.08.05 |
| 29 | | | | |
| 30 | **Galvanic Decoupler** | **40 Tage** | **Mit 01.06.05** | **Die 26.07.05** |
| 31 | Design | 2 Wochen | Mit 01.06.05 | Die 14.06.05 |
| 32 | Review & Approval | 2 Wochen | Mit 15.06.05 | Die 28.06.05 |
| 33 | Production | 1 Monat | Mit 29.06.05 | Die 26.07.05 |
| 34 | | | | |
| 35 | System Integration and Final Test | 1 Monat | Mon 12.09.05 | Fre 07.10.05 |
| 36 | | | | |
| 37 | Shipping to Pole | 2 Wochen | Mon 05.12.05 | Fre 16.12.05 |
| 38 | Installation at Pole | 14 Tage | Mon 19.12.05 | Don 05.01.06 |




# Prospects
# Global Trigger and Eventbuilding


## Global Trigger:

- DMAD Trigger: AMANDA can trigger IceCube using the DOM-SYNC option, Amanda can not be triggered (?) without soft.-trigger
- A special trigger CPU gathers IceCube and TWR Triggers (TCP/IP ?) and sends readout request after error checking to the respectively other system
  (Error, time-out/maximum latency delay is checked here or there)

## Event building:

- Common event-building becomes easier with the similar data-model of the GPS-DSB option. A special process has to react on the triggers, gather AMANDA data (error checking) and feed them into the IceCube data stream ?

The planned setup in Wuppertal can be used to develop and realistically test these procedures with only minor upgrades (PC which simulates the IceCube Trigger and DAQ)


# Summary


- We have developed a scheme for the synchronization of AMANDA and IceCube, which is essentially a combination of the advantages of previously proposed methods.
- We propose to implement this scheme after realistic tests (in the Northern hemisphere) during the next South-Pole season.
- The here presented scheme leads to an AMANDA data-model which looks similar to IceCube. It has prospects for a future global trigger and a combined event-building.
- We request 3 optical and 1 electrical cable from the IceCube counting house to MAPO
- We would strongly benefit from a fast decsion, preferably during this meeting until Easter.